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The path for the development and release of heat-tolerant soybean lines

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High ambient temperatures can damage soybean seed. Heat is recognized by the crop insurance industry as a major cause for monetary losses to producers. The USDA Risk Management Agency reported payouts to soybean farmers of more than $247 million on over 1.62 million hectares for losses due to heat damage from 2007-2016. Heat damage can be accentuated when soybean genotypes mature during high temperatures, such as encountered in the early soybean production system of the mid Southern U.S.A. USDA-ARS researchers identified specific temperatures that damage soybean seed, determined that soybean genotypes differ in their response to damaging temperatures, determined that the common gene pool lacks heat tolerance, and identified accessions with heat tolerance within the USDA germplasm collection. Genetic and breeding programs were initiated to identify specific traits affected by high temperatures, determine the inheritance of tolerance to heat damage for each trait, and develop improved soybean lines with heat tolerance. Two new single genes at independent loci were identified, mapped, and named (*wri* and *Isc*) for high-heat-induced seed wrinkling and impermeable seed coat, respectively. Heat tolerant accessions and associated molecular markers have been made publicly available for each of these genes. A single major QTL peak was identified affecting high seed germinability across four environments. Pedigree selection in multi-year high-heat environments proved to be an effective strategy to simultaneously select for multi-genic heat tolerance traits (high germination in standard and accelerated-aging assays, permeable seed coats, and non-wrinkled non-green seed) in agronomically-improved genotypic backgrounds. As a result, multiple improved heat-tolerant germplasm lines have been developed and made available to commercial and public researchers for breeding and research purposes. The USDA-ARS developed DS25-1 (MG IV), the first improved soybean germplasm line with heat tolerance released in the U.S.A. Additional genetic studies, as well as stacking with other value-added traits, are in progress.